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(71)Applicant : CANON INC

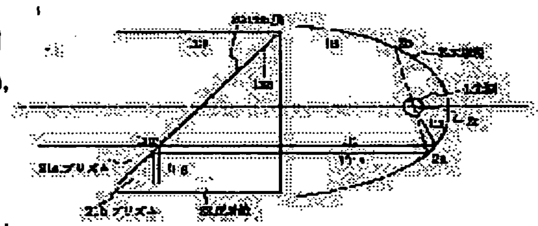
(72)Inventor : KIMURA KAZUMI

(54) POLARIZED LIGHT ILLUMINATION DEVICE AND PROJECTION TYPE DISPLAY DEVICE USING THE SAME

(57)Abstract:

PURPOSE: To provide the polarized light illumination device which can modulates the vibration direction of polarized light without using any optical phase plate and has high light utilization efficiency.

CONSTITUTION: The device consists of a light source 1, a light converging means which consists of a reflecting mirror 2 provided behind the light source 1, polarized light separating means 20, 21a, and 21b which separate the light from the light converging means into 1st and 2nd polarized light beams differing in polarizing direction, and a recurrence means 23 which returns the 1st polarized light to the light converging means; and the 1st polarized light from the recurrence means 23 is made obliquely incident on the reflecting mirror 2 of the light converging means and reflected and then the vibration direction of the 1st polarized light is modulated to project the light again.



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(71)出願人　000001007
キヤノン株式会社
東京都大田区下丸子3丁目30番2号

(72)発明者　木村　一己
東京都大田区下丸子3丁目30番2号キヤノン株式会社内

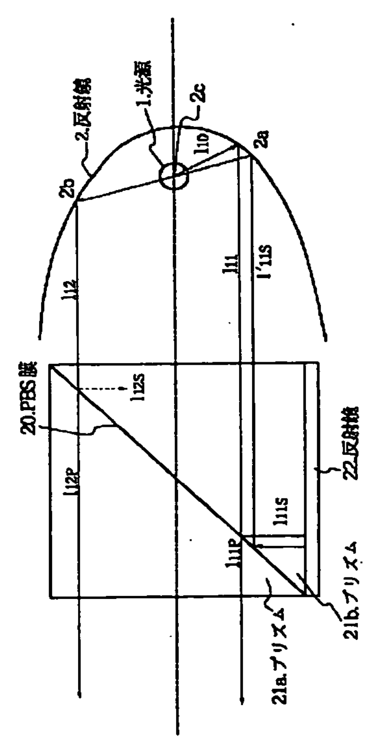
(74)代理人　弁理士　丸島　儀一

(54)【発明の名称】　偏光照明装置及び該偏光照明装置を用いた投写型表示装置

(57)【要約】

【目的】　光学位相板を用いずに、偏光光の振動方向を変調できる光利用効率の高い偏光照明装置を提供する。

【構成】　光源と、該光源の背面に設けた反射鏡からなる集光手段と、該集光手段からの光を互いに偏光方向が異なる第1、第2の偏光光に分離する偏光分離手段と、前記第1の偏光光を前記集光手段に戻す再帰手段のみからなり、前記再帰手段からの第1の偏光光を前記集光手段の反射鏡で斜入射反射させることにより前記第1の偏光光の振動方向を変調して再び出射するよう構成した。



【特許請求の範囲】

【請求項１】　光源と、該光源の背面に設けた反射鏡からなる集光手段と、該集光手段からの光を互いに偏光方向が異なる第１、第２の偏光光に分離する偏光分離手段と、前記第１の偏光光を前記集光手段に戻す再帰手段のみからなり、前記再帰手段からの第１の偏光光を前記集光手段の反射鏡で斜入射反射させることにより前記第１の偏光光の振動方向を変調して出射することを特徴とする偏光照明装置。

【請求項２】　前記光源は、メタルハライドランプ、キセノンランプ等の放電管型光源を用いることを特徴とする請求項１記載の偏光照明装置。

【請求項３】　前記集光手段は放物形状によって構成される回転体、柱形状体鏡であり、該放物形の焦点近傍に前記光源を配置したことを特徴とする請求項１又は２記載の偏光照明装置。

【請求項４】　前記集光手段は楕円形状によって構成される回転体、柱形状体鏡を備えており、該楕円形の焦点近傍に前記光源を配置したことを特徴とする請求項１又は２記載の偏光照明装置。

【請求項５】　前記集光手段は、前記光源から発する光のうち前記偏光分離手段以外へ向かう光を前記光源へ戻す為の反射手段を備えたことを特徴とする請求項１、２、３又は４記載の偏光照明装置。

【請求項６】　前記再帰手段が、前記集光手段へ戻される前記第一の偏光光の少なくとも一部が前記光源を通過しないように構成されていることを特徴とする請求項１、２、３、４又は５記載の偏光照明装置。

【請求項７】　前記偏光分離手段は、誘電体多層膜からなる偏光分離作用膜を備えることを特徴とする請求項１、２、３、４、５又は６記載の偏光照明装置。

【請求項８】　偏光照明装置と、該偏光照明装置からの偏光光を変調することにより画像光を形成する画像光形成手段と、該画像光形成手段により形成された画像光を投影する投影手段とを有する投写型表示装置において、前記偏光照明装置は、光源と、該光源の背面に設けた反射鏡からなる集光手段と、該集光手段からの光を互いに偏光方向が異なる第１、第２の偏光光に分離する偏光分離手段と、前記第１の偏光光を前記集光手段に戻す再帰手段のみからなり、前記再帰手段からの第１の偏光光を前記集光手段の反射鏡で斜入射反射させることにより前記第１の偏光光の振動方向を変調して出射することを特徴とする投写型表示装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は偏光照明装置及び該偏光照明装置を有する投写型表示装置に関するものである。

【０００２】

【従来の技術】図１３は偏光照明装置を用いた投写表示装置の従来例の１つを示す要部構成図である。１は光源、２は反射鏡、６は偏光ビームスプリッタ、２０は偏光分離作用膜、７は液晶ライトバルブ、１３はλ／４光学位相板である。図１３において２つの偏光分離作用膜２０_1と２０_2はほぼ９０度の角度で互いの端部が接している。反射鏡２によって略平行光となった光源１からのランダム光Ａｏは偏光ビームスプリッタ６の第１の偏光分離作用膜２０_1により、Ｐ偏光光$Ａｐ_1$は透過され、Ｓ偏光光Ａｓは反射される。Ｓ偏光光Ａｓは更に光路に設置されている第２の偏光分離作用膜２０_2で反射され、光学軸が所望の方向に設定されているλ／４光学位相板１３を通過後、円偏光光Ａｒとなり、光源１、反射鏡２を介して再度λ／４光学位相板１３を通過する事によりＰ偏光光を含む光$Ａｐ_2$となって偏光分離作用膜２０_1を透過し、液晶ライトバルブ７に入射する。

【０００３】この投写表示装置は、偏光分離作用膜２０_1又は２０_2で分離されるＰ偏光光ＡｐとＳ偏光光Ａｓの両偏光光を、同じ偏光方向を持つ偏光光とし、液晶ライトバルブ７を照明しようとするもので、偏光照明装置を用いない投写表示装置に比べて光利用効率のアップが図れる。

【０００４】

【発明が解決しようとする課題】しかしながら、従来例では光学位相板を用いている為、光が通過する際、吸収や反射によって光量が低下してしまう。一般に使われている、プラスティック製の光学位相板は光の透過率が約９０％であり、特に従来例で示した、一度光源１に戻ってから出射する光束は、光学位相板を計３回通過することになるので、大幅に光量を損失してしまう。

【０００５】

【課題を解決するための手段】本発明は、上記課題を解決する為に成されたものであり、本発明は、光源と、該光源の背面に設けた反射鏡からなる集光手段と、該集光手段からの光を互いに偏光方向が異なる第１、第２の偏光光に分離する偏光分離手段と、前記第１の偏光光を前記集光手段に戻す再帰手段のみからなり、前記再帰手段からの第１の偏光光を前記集光手段の反射鏡で斜入射反射させることにより前記第１の偏光光の振動方向を変調して出射することを特徴とする。

【０００６】

【実施例】図１に本発明の実施例を示す。

【０００７】１は光源としてのメタルハライドランプ、２は集光手段としての回転放物面形状をした反射鏡、２０は偏光分離作用膜（以下、ＰＢＳ膜と記す）、２１ａ、２１ｂは直角プリズム、２２は平面反射鏡であり、偏光分離手段はＰＢＳ膜２０、直角プリズム２１ａ、２１ｂ、平面反射鏡２２から構成される。光源１は放物面鏡２の焦点位置２ｃに設けられ、これによって略平行光束を得ることができる。略平行光束は偏光ビームスプリッタで２つの直線偏光光に分離され、一方の偏光光は偏光ビームスプリッタの一方の出射面に設けられた平面反

射鏡２２によって垂直反射され、放物面鏡２に戻る光束（以下、再帰光と記す）となる。

【０００８】次に、不定偏光光である略平行光から直線偏光光を得るまでの過程を具体的に説明する。

【０００９】放物面鏡２の焦点２ｃに置かれた光源の中心から発した光線l_{10}は、放物面鏡２によって平行光l_{11}になりプリズム２１ｂに入射する。この時l_{11}は偏光方向が不定である自然光である。ＰＢＳ膜に達した光線l_{11}はここで偏光分離作用を受け、偏光方向の異なる一対の直線偏光光l_{11P}、l_{11S}に分離される。l_{11P}は偏光方向、つまり偏光の振動方向が紙面内にあり一般にＰ偏光光と呼ばれ、ＰＢＳ膜２０を透過して２１ａプリズム内を進み光線l_{11}の入射面と反対側にある出射面から出射し、偏光照明光となる。

【００１０】一方、l_{11S}は偏光の振動方向が紙面に垂直で一般にＳ偏光光と呼ばれ、ＰＢＳ膜２０により垂直に反射され２１ｂプリズム内を平面反射鏡２２方向へ進む。平面反射鏡２２はＳ偏光光l_{11S}の進行方向に対して垂直に設置されているので、Ｓ偏光光は進行方向を１８０度変えて再びＰＢＳ膜２０方向へ進む。l_{11S}はＳ偏光光なのでＰＢＳ膜２０で再び反射されて、ＰＢＳ膜２０へ向かって来たときと同一の光路（図では分かりやすくするために反射前後の光路をずらして示した）を反対に戻り放物面鏡２への再帰光l_{11S}'になる。再帰光l_{11S}'は平行光束であるので放物面鏡２上の点２ａで反射されて焦点２ｃにある光源１に戻る。

【００１１】再帰光l_{11S}'はあたかも光源１から発した光のように再び放物面鏡２に向かい、点２ｂで反射さ＊れ平行光束l_{12}となってプリズム２１ｂへ再入射する。平行光束l_{21}は後述する事情により、偏光状態が大幅に乱されており、ＰＢＳ膜２０で一対の直線偏光光l_{12P}とl_{12S}に分離される。l_{12P}はl_{11P}と同様、Ｐ偏光光でありＰＢＳ膜を透過してプリズム２１ａ中を進み出射して、偏光照明光となる。一方、l_{12S}はl_{11S}と同様に平面反射鏡２２を介して光源へ戻る再帰光として振る舞う。以上のような過程を繰り返して、原理的には自然光をすべて偏光光に変換することができる。

【００１２】偏光分離手段によって分離され、集光手段に戻された後の直線偏光光の偏光状態の変化について図２、図３を用いて説明する。

【００１３】図２に於て、放物面鏡２上の２点２ａ、２ｂで再帰光l_{21}が反射され、l_{22}、l_{23}となって出射する。２ｃは放物面鏡２の焦点、Ｇａ、Ｇｂは点２ａ、２ｂの接平面、Ｈａ、Ｈｂは点２ａ、２ｂの法線を示す。

【００１４】再帰光l_{21}の振動方向は紙面に対してα_iだけ傾いている。α_iは方位角と呼ばれ、光の伝播方向に対して振動方向が時計回りに回る時を正とする。図３はこの方位角α_iを説明するもので、図１の反射鏡２の開口をＰＢＳ膜の置いてある方向から見ており、図３中m_1を含む面は図１に於て紙面内にあり、m_2を含む面は図１に於て紙面に垂直である。図３中矢印で再帰光l_{21}の振動方向を示している。この振動方向からα_iだけ回転させたm_3で切り取られた断面図が図２である。

【００１５】前述したように再帰光l_{21}は直線偏光光であり、直線偏光光がある境界面で反射（例えば図２の点２ａでの反射）する場合、一般に

$$\tan\alpha_r = -\tan\alpha_i \{\cos(\theta_i - x) / \cos(\theta_i + x)\}$$
・・・１式

但し、$\sin x = \sin\theta_i / n$
・・・２式

が成立する。α_iは光l_{21}の入射時の方位角（図３に示すように振動方向と平面m_3のなす角と呼ぶ事にする）、α_rは反射時の同じく方位角、ｎは放物面鏡２の屈折率、θ_iは平面Ｇａ、Ｇｂに対する入射角である（「光学の原理、東海大出版会」より）。

【００１６】屈折率ｎは放物面鏡２が誘電体であるなら実数、導体であるなら複素数をとり、これにより反射後の偏光状態の変化の仕方が違ってくる。

【００１７】まず誘電体、つまり屈折率ｎが実数の場合について述べる。ｎは光l_{21}が進行している空間の媒質※（図２では空気）からみた放物面鏡２の媒質の屈折率でありｎ＞１である。このため、２式よりｘも実数で表され、１式よりα_rも実数となる。よって１式より振動方向は平面m_3から遠ざかる方向に回転する（「光学の原理」Ｐ７１より）。その時のα_rはθ_iによって異なることは１式、２式よりわかる。また、図２からもわかるようにθ_iは$0 < \theta_i < \theta_{imax}$（$\theta_{imax}$は点２ａが放物面鏡２の端部であるとき）とあらゆる値を取るので、光l_{22}の方位角もあらゆる値を取る。

【００１８】また、点２ｂでの反射に於ても入射角が、

$$\theta_{ib} = \pi / 2 - \theta_{ia}$$
・・・３式

を満たしながらあらゆる値を取るので、結果として光l_{23}の方位角もあらゆる値を取る可能性があり、図２の紙面内を進行する光l_{23}を含む出射光の振動方向はバラバラで、トータル的にみて偏光していない状態となる。２は回転放物面鏡であることから当然光l_{21}の方位角α_iも、$-\pi/2 < \alpha_i < \pi/2$の間であらゆる値をとるので、この点からもトータル的に放物面鏡２からの出射光の偏光がくずれることがわかる。

【００１９】よって、放物面鏡２を介した光l_{23}は図１に示したＰＢＳ膜２０で一対の相異なる直線偏光光に再び分離されるのである。

【００２０】一方、放物面鏡２が導体の場合、つまり屈折率ｎが複素数を取る場合は事情が異なる。ｎが複素数であることから２式よりｘが複素数になる。よって、１式よりα_rが複素数となるため、位相とびが生じて反射した光l_{22}は一般に楕円偏光光となる（「光学の原理」

P911より）。
【0021】楕円偏光光となった光l_{22}が次の反射点2＊bに於て反射することによって再び直線偏光光となるための必要条件のひとつは

$$\theta_{ia}=\theta_{ra}=\theta_{ib} \quad \cdots 4式$$

である（θ_{ra}は点2aでの反射角）。なぜなら直線偏光光が入射角θ_iで入射した界面で、反射角θ_r（$=\theta_i$）で反射され、位相差δが生じて楕円偏光光になるとき、光の逆進性から位相差$-\delta$の楕円偏光光が入射角θ_r（$=\theta_i$）で同様な界面に入射して反射されると直線偏光光になる。つまり、直線偏光光と、位相差がδである楕円偏光光が、反射によって可逆になるためには少なくとも4式を満たすことが必要となる。
【0022】今、$\theta_{ia}+\theta_{ib}=\pi/2$であることから4式は一般には満たされない。例え満たしたとしても、図2のような放物面鏡2の反射点2a、2bで夫々$\pi/2$だけ位相差が生じないとl_{23}はl_{21}と同じ振動方向を持つ直線偏光光になり得ない。よって、l_{23}が直線偏光光になることはないと考えてよいので図1で示したPBS膜20で、一対の直線偏光光に分離されるのは明らかである。
【0023】ところで、方位角$\alpha_i=0$または$\pi/2$の時、光l_{21}と光l_{23}の振動方向は一致し、つまり振動方向が放物面鏡2を介しても回転せずPBS膜に対して常にS偏光光として作用し、PBS膜20を介して平面反射鏡22と放物面鏡2を行ったり来たりして照明光として作用しないという事態が生じる。
【0024】また、誘電体の反射面での反射の時、振動方向の回転（αの変化）が小さく光l_{23}のPBS膜20に対してのP偏光光の成分がS偏光光の成分より少ないということや、導体の反射面での反射の時、生じる位相差が小さい等の状態が生じて直線偏光光に近い楕円偏光光となり、同じくPBS膜20に対してのP偏光光の成分が少ない、ということが生じる場合がある。このような時、再帰光l_{21}の振動方向を積極的に乱すために、光源ランプの表面を拡散面にするとよい。
【0025】拡散面は通常、微小なプリズムが多数表面を覆った状態と考えられ、プリズムには偏光光の振動方向を変化させる能力が一般には非常に小さいため、拡散面も偏光光の振動方向を変化させる能力が非常に小さい。しかしながら、拡散面は光の進行方向を変化させることができ、例えば図4のようにある振動方向を持った偏光光l_{22}が光源1の表面で拡散されて偏光光l_{221}、l_{222}、l_{223}、l_{224}のように分岐し、放物面鏡2の様々な点で様々な入射角、方位角で反射することにより、偏光光l_{23}以外にそれぞれ異なった偏光光l_{231}、l_{232}、l_{233}を得ることができて、偏光光の振動方向を更に乱すことができる。
【0026】拡散面をランプ表面もしくは近傍に設ける理由は、拡散面で拡散された光をあたかも光源1から発した光のように振る舞わせるためである。仮にそれ以外の場所に拡散面があると、集光手段によって略平行光が得られなくなってしまう。
【0027】本実施例のPBS膜は一般に誘電多層膜によって形成され、2つの直角プリズム21a、21bの間に挟まれて接着されており、一般に言う偏光ビームスプリッタである。入射角が45度の光に対してP偏光光とS偏光光に分離するように設計されている。入射角が45度から大巾にずれない限り、他の入射角の光に対応した偏光ビームスプリッタも製作可能である。
【0028】平面反射鏡22は一般にはガラス平面上にアルミ蒸着したものが用いられるが、反射率向上のために増反射コートを設けるなどの対策を行ってもよい。また、偏光ビームスプリッタによって分離されたS偏光光の進行方向に対して反射面が垂直になるように設置されなければならない。
【0029】放物面鏡2は、光源1が多量の赤外光を放出しているので、被照明体の昇温を防止する為にコールドミラーで形成するとよい。本実施例ではその断面の形状が一般に$y=ax^2$で表せるような回転放物面形状の反射鏡を用いたが、光源の発光特性に合わせてより集光性を高める為に$y=ax^2+bx^4+cx^6$（$a \gg b$、c）で表せるような断面を持った略放物形のものを用いてもよい。また、楕円形状の反射鏡と屈折素子を組み合わせた集光手段を用いてもよい。その他集光率を向上させるために複数の鏡面で構成したり、補助の鏡を用いて集光手段から出射される光束の断面形状を調整したり、また他の非球面を導入した集光手段など、略平行光が得られる構成であれば殆どの集光手段が適用できる。但し、より好ましくは、反射に於ける損失が少ないならば集光手段へ戻された光の反射鏡での反射回数の多いほうが、偏光光の振動方向をより乱すことができるので望ましい。
【0030】本発明の偏光照明装置は集光手段の反射鏡へ向かう再帰光が従来例のようにλ／4光学位相板を通過しないため、直線偏光光のままなので、
1．反射時に於ける直線偏光光の振動方向の旋回。
2．更に導体の反射鏡の場合、反射時の位相とびによる直線偏光光から楕円偏光光への変調。
の2つの作用により、再帰光を、PBS膜20で再びP偏光光とS偏光光に分離できるような光にすることができる。
【0031】以下に本発明の偏光照明装置の他の実施例を示す。
【0032】図5（a）はプリズム21a、21bとPBS膜20で形成された偏光ビームスプリッタによって分離されたP偏光光を、放物面鏡22で集光手段つまり放物面鏡2へ戻すような構成となっており、第1の実施例でのS偏光光を集光手段へ戻すという点に対しての差

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異となっている。

【0033】図5（b）は及び図5（c）の実施例はＰＢＳ膜２０を、断面が直角三角形の形状をした三角柱プリズム２１ｃ、２１ｄでぞれぞれ挟んで接着したものである。図５（ｂ）に於て集光手段（放物面鏡２）を介してプリズム２１ｃに入射した光はＰＢＳ膜２０若しくは全反射面ｃに達する。ＰＢＳ膜２０に達した光はＰＢＳ膜２０によってＳ偏光光とＰ偏光光に分離され、Ｐ偏光光はプリズム２１ｄの出射面から出射し、Ｓ偏光光はＰＢＳ膜で反射されて全反射面ｃに達し、更にここで反射されて集光手段へ戻る再帰光となる。

【0034】一方、プリズム２１ｃに入射した光のうち全反射面ｃに達した光は、ここで反射されてＰＢＳ膜２０へ向かう。そしてＰＢＳ膜２０でＳ偏光光とＰ偏光光に分離されてＳ偏光光は反射され集光手段へ向かう再帰光となる。Ｐ偏光光は全反射面ｄによって反射され出射面より出射する。

【0035】図５（ｃ）に於て集光手段（放物面鏡２）を介してプリズム２１ｃに入射した光もＰＢＳ膜２０若しくは全反射面ｃに達する。ＰＢＳ膜２０に達した光はＰＢＳ膜２０によってＳ偏光光とＰ偏光光に分離され、Ｐ偏光光は全反射面ｄによって反射された後出射面から出射し、Ｓ偏光光はＰＢＳ膜で反射されて全反射面ｃに達し、更にここで反射されて集光手段へ戻る再帰光となる。

【0036】一方、プリズム２１ｃに入射した光のうち全反射面ｃに達した光は、ここで反射されてＰＢＳ膜２０へ向かう。そしてＰＢＳ膜２０でＳ偏光光とＰ偏光光に分離されてＳ偏光光は反射され集光手段へ向かう再帰光となる。Ｐ偏光光はプリズム２１ｄの出射面より出射する。

【0037】図６の実施例では、断面が直角三角形の形状をした３つの三角柱プリズム２１ｅ、２１ｆ、２１ｇが図のように組み合わされており、夫々のプリズムの境界面にＰＢＳ膜２０ａ、２０ｂが設けられている。

【0038】放物面鏡２を介して入射してきた光はプリズム２１ｅを透過してＰＢＳ膜２０ａまたは２０ｂでＰ偏光光とＳ偏光光に分離され、Ｐ偏光光はそのまま出射面から出射し、Ｓ偏光光は他方のＰＢＳ膜で反射されて放物面鏡２へ戻る再帰光となる。

【0039】図５（ｂ）、図５（ｃ）、図６で示した実施例は図１や図５（ａ）に於ける実施例に比べてプリズムで形成される部分が約半分の体積になるので、コンパクトかつ安価な偏光照明装置が実現できるという効果も有する。

【0040】図７の実施例は前記各実施例で用いたプリズム及びＰＢＳ膜の代わりにガラス平板層２３を用いている。一般にブリュースター角θ_iを保っていればガラス平板でも偏光分離特性を有するので、ガラス平板を複数枚重ねればＰＢＳ膜を形成しなくても、偏光分離手段とすることができる。重ねる枚数が多い程偏光分離性能は良くなるが透過率が低くなる可能性があるので必要に応じてガラス平板間に誘電体多層膜によるＰＢＳ膜を設けてもよい。平面反射鏡２２はガラス平板層２３で反射される光を、同じ光路で戻す様に前記反射される光に対して垂直に配置されている。

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【0041】図７（ｂ）は図７（ａ）の応用例で、ガラス平板層２３と平面反射鏡２２を一つの単位として、集光手段の光軸を対称軸にして二組設けたものである。

【0042】図７（ａ）、（ｂ）の実施例はプリズムを用いた実施例に比べて軽量、安価になる。また、図７（ｂ）の実施例は図７（ａ）の実施例に対して部品点数は増えるが、小型化できるというメリットがある。

【0043】尚、図５から図７の実施例に於て集光手段へ戻される再帰光は、図１で示した実施例と同様に、集光手段である放物面鏡２での反射によって偏光状態を乱されて再び集光手段から出射してくる。

【0044】図８は他の実施例で、二組の光源と集光手段を有している。一方の集光手段からの光のうちＰＢＳ膜２０で反射されたＳ偏光光は他方の集光手段へ向かうように構成されており、双方の集光手段からの光のうちＰＢＳ膜２０を透過するＰ偏光光どうしを同一の方向に向けるための反射面２２を有するプリズム２１ｈを備えている。

【0045】図９は他の実施例で、二組の光源、集光手段、ＰＢＳ膜を有している。図９（ａ）では一方の集光手段からの光のうち一方のＰＢＳ膜で反射されたＳ偏光光は他方のＰＢＳ膜を介して他方の集光手段へ向かうように構成されており、双方の集光手段からの光のうちＰＢＳ膜を透過するＰ偏光光どうしは、同一の方向へ出射する。

【0046】図９（ｂ）では一方の集光手段からの光のうち一方のＰＢＳ膜を透過したＰ偏光光は他方のＰＢＳ膜を介して他方の集光手段へ向かうように構成されており、双方の集光手段からの光のうちＰＢＳ膜で反射するＳ偏光光どうしは、同一の方向へ出射する。

【0047】図８、図９の実施例は、光源を２個用いているので、大幅な光量アップが計れる。通常、光量を上げるには単純に光源の出力を上げることが考えられるが、光源の出力を上げると必然的に光源の発光部が大きくなってしまい、集光手段を介した光の平行性が悪くなってしまう。液晶ライトバルブのような角度依存性のある被照明体を照明する場合、照明光は平行光に近いことが必要条件となるので、本実施例のように発光部を大きくせずに光量アップが図れるのは、非常に好ましい。

【0048】図１０に他の実施例を示す。本実施例は、図５（ｂ）または図６の実施例のプリズムによる構成部分を小型にして、同一平面上に複数個並べたものである。本図に於て２０はＰＢＳ膜、２０′はＰＢＳ膜または反射膜である。

【００４９】次に、再帰光の平行性の低下を最小限にするための実施例を以下に示す。ランプの管球部表面で再帰光が散乱する用に構成すると、ランプ管球部表面を二次光源として前記再帰光が振る舞うので、ランプの径が実質的に大きくなったことになり、平行性が低下してしまう。よって平行性の低下を最小限にする為にはランプの管球部表面で散乱が起きない様な光源を用いればよい。具体的にはランプの管球部を滑らかにするなどの方法が考えられる。また、一般にはメタルハライドランプよりキセノンランプのほうが管球部を滑らかに形成することができるので、ランプの管球部に光が当たっても散乱しにくいランプを形成しやすくなる。

【００５０】更に、再帰光がランプ管球部及び発光部を通過する際に吸収され、ひいては損失光となってしまうのを防ぐ為の実施例を図１１に示す。

【００５１】本実施例が図５（ｂ）の実施例と異なるところはプリズム２１ｃをプリズム２１ｃ′に置き換えた点のみである。

【００５２】本実施例は、直角三角形を断面とする三角柱の形状をした直角プリズム２１ｄと、該直角プリズム２１ｄの直角を挟んでいる面と、同じ形、同じ面積を持つ面を備えた、直角に近い鋭角プリズム２１ｃ′（図中破線を含んだ断面積が直角三角形である）を図のように張り合わせたものであり、張り合わせ面にＰＢＳ膜２０を設けたものである。尚、多層膜であるＰＢＳ膜２０は直角プリズム２１ｄ、鋭角プリズム２１ｃのどちらか一方の面のみに設けて張り合わせても良いし、互いの面に設けて張り合わせても良い。また、必要に応じて全反射面ｃ、ｄにアルミ蒸着などを施しても良い。

【００５３】図１１において放物面鏡２を介して平行化された平行光l_{11}は、ＰＢＳ膜２０により平行光l_{11}のうちＰ偏光光l_{11P}はそのまま透過して直角プリズム２１ｄより出射される。一方ＰＢＳ膜２０で反射されたＳ偏光光l_{11S}は全反射面ｃで反射され、再帰光l_{11S}'となる。ＰＢＳ膜２０と全反射面ｃは直角をなしていないので、再帰光l_{11S}'は前記平行光l_{11}とは平行とならずに放物面鏡２へ向かう。再帰光l_{11S}'は、放物面鏡２を介して該放物面鏡２の焦点位置に置かれた光源１へと向かう。ここで、放物面鏡２で反射することによって偏光光の振動方向が乱れる原理は第１の実施例と同様なので省略する。また、前述したように再帰光l_{11S}'は平行光l_{11}と平行でないために放物面鏡２で反射されても正確に光源１へは向かわず、発光部を避けて通過する事になる。発光部を避けて通過した、つまり発光部によって吸収されない再帰光l_{11S}は再び放物面鏡２を介して光l_{12}となってプリズム２１ｃ′へ再入射し、ＰＢＳ膜２０で光l_{12P}と光l_{12S}に再び分離される。本実施例においてはＰＢＳ膜２０を介して放物面鏡２及び光源１へ戻ってくる光束の光軸が光源の発光部を通過しないというところが本質なので、全反射面ｃが平行光l_{11}と４５度をなすようにし、ＰＢＳ膜２０が平行光l_{11}と４５度以外の角をなすように設定しても構わない。また、ＰＢＳ膜２０と全反射面ｃの一方又は両方に曲率を持たせる事によって再帰光の光路が発光部を通過しないようにする事も出来る。このとき留意すべき事は、平行光でなくなった光l_{12}のＰＢＳ膜２０への入射角が、角度依存性のあるＰＢＳ膜２０の許容角度を大幅に越えないことである。

【００５４】本実施例は図５（ｂ）の応用例と考えることができるが、他の実施例においても光を光源の方面へ戻す為の平面反射鏡や全反射面の傾きを変えたり、曲率を持たせることによって本実施例と同様の効果を持たせることができる。

【００５５】図１２に本発明の投写型表示装置の実施例を示す。偏光照明装置２４は前述したような実施例のうちのいずれかを用いている。

【００５６】偏光照明装置２４からの偏光光は液晶ライトバルブ７を通過することによって、画像情報を含んだ光束となり、偏光板８で画像光のみ透過し、投写レンズ１０を介して不図示のスクリーンに該画像光が投影される。

【００５７】色分解光学系を偏光照明装置２４と液晶ライトバルブ７の間に、色合成光学系５を液晶ライトバルブ７と投写レンズ１０の間に設け、各色の光路毎に液晶ライトバルブを設けてもよい。また、色分解光学系の一部もしくは全部を偏光照明装置の集光手段と偏光分離手段の間に設けてもよい。この場合、複数の偏光分離手段が必要となるが、一般にＰＢＳ膜には波長依存性があるので、色分解した後に夫々の色光に適したＰＢＳ膜を容易すれば、効率アップ、良好な色再現性に関するよりよい設計が可能となる。

【００５８】また、色合成光学系を用いずに複数の投写レンズで投写し、スクリーン上で複数の画像光を合成してもよいし、色分解光学系を用いずに偏光照明装置を複数用意し、それらに対応する液晶ライトバルブを照明してもよい。

【００５９】図１２の実施例に於て、液晶ライトバルブ７の前に検光子としての偏光板を設ければ、液晶ライトバルブ７に入射する偏光光の偏光比を更に高めることができる。

【００６０】尚、本発明は以上の実施例に限定されるものではなく、発明の主旨を逸脱しない範囲で、種々の構成が可能であることはいうまでもない。

【００６１】

【発明の効果】以上説明したように本発明は、光源と、該光源の背面に設けた反射鏡からなる集光手段と、該集光手段からの光を互いに偏光方向が異なる第１、第２の偏光光に分離する偏光分離手段と、前記第１の偏光光を前記集光手段に戻す再帰手段のみからなり、前記再帰手段からの第１の偏光光を前記集光手段の反射鏡で斜入射

反射させることにより前記第１の偏光光の振動方向を変調して出射するので、光の損失の少ない偏光照明装置が実現できる。また、λ／４光学位相板は一般に波長依存性を有するので、λ／４光学位相板を用いずに偏光光の振動方向を変調できるということは色むらを防ぐという意味でも効果がある。

【図面の簡単な説明】

【図１】本発明の偏光照明装置の実施例の作用説明図

【図２】本発明の偏光照明装置の作用の原理説明図

【図３】本発明の偏光照明装置の作用の原理説明図

【図４】本発明の偏光照明装置の他の実施例

【図５】本発明の偏光照明装置の他の実施例

【図６】本発明の偏光照明装置の他の実施例

【図７】本発明の偏光照明装置の他の実施例

【図８】本発明の偏光照明装置の他の実施例

【図９】本発明の偏光照明装置の他の実施例

【図１０】本発明の偏光照明装置の他の実施例

【図１１】本発明の偏光照明装置の他の実施例

【図１２】本発明の投写型表示装置の実施例

【図１３】従来の投写型表示装置の概略構成図

【符号の説明】

1　光源

2　反射鏡

7　液晶ライトバルブ

6　偏光ビームスプリッタ

8　偏光板

１０　投写レンズ

１３　λ／４光学位相板

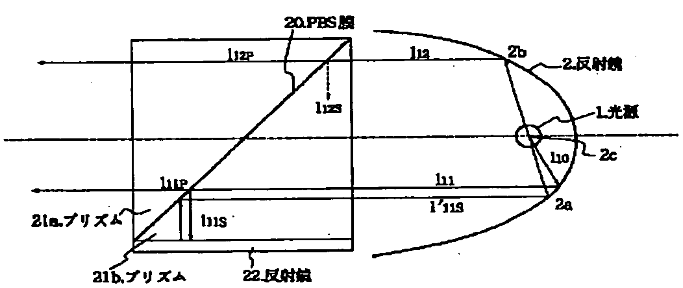
２０　偏光分離作用膜（ＰＢＳ膜）

２１　プリズム

２２　平面反射鏡

２４　偏光照明装置

【図１】



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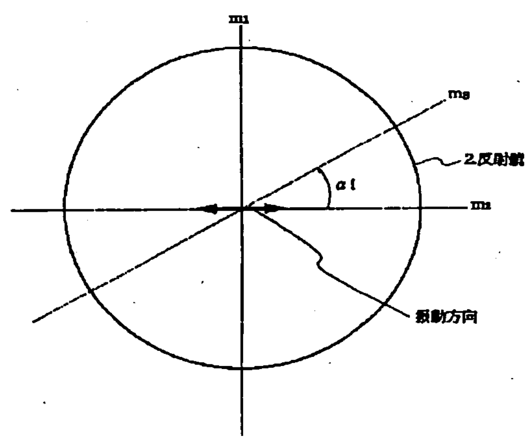

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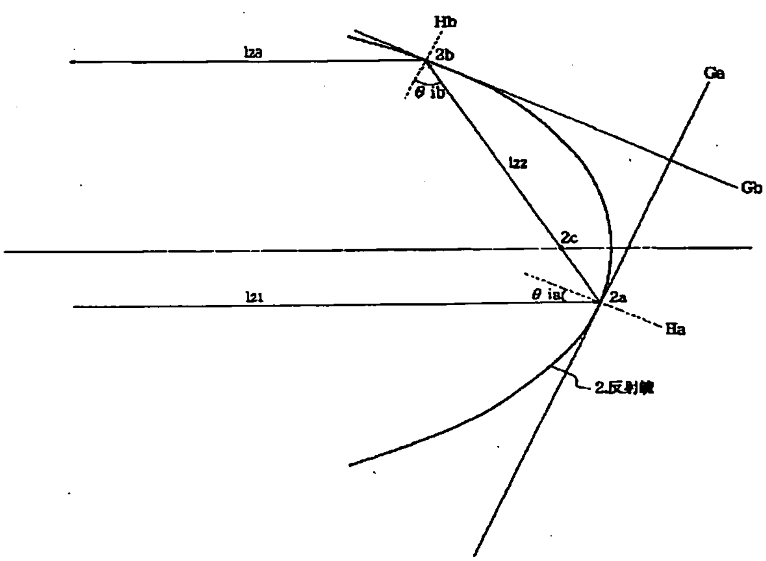
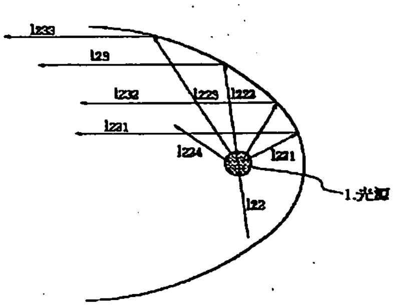
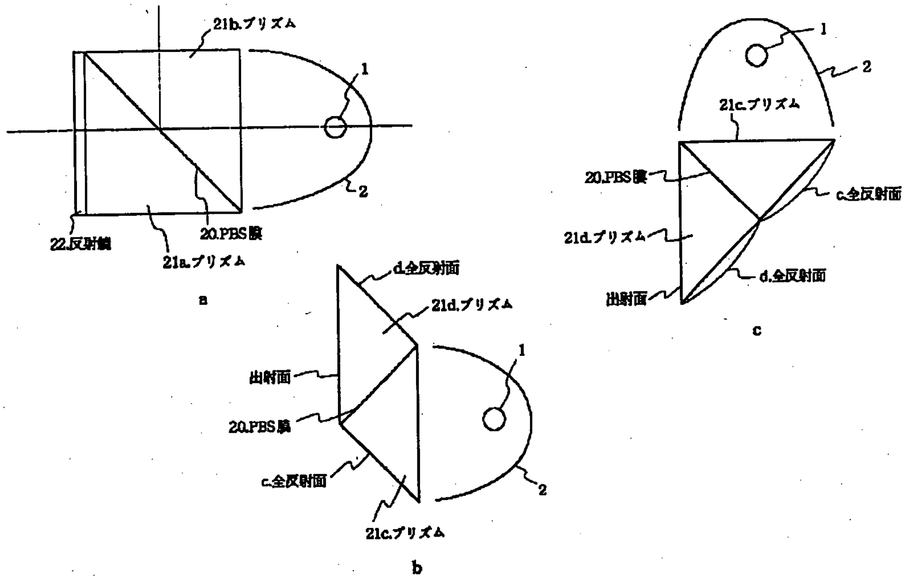


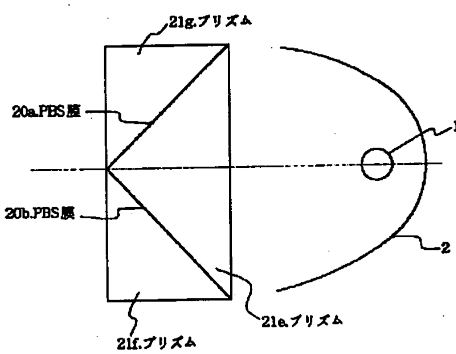
【図４】



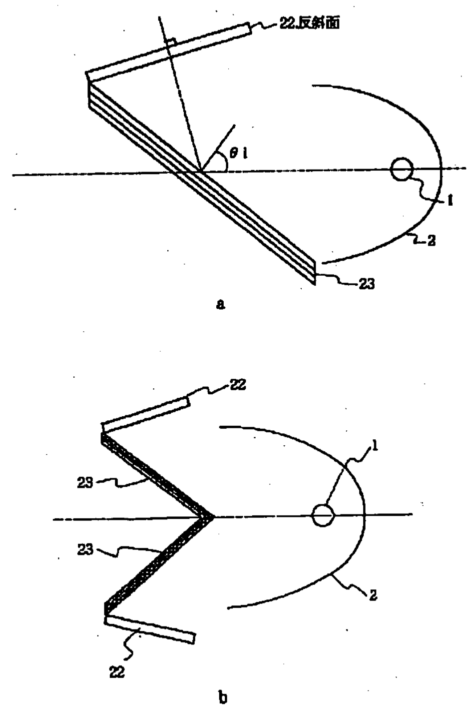
【図5】


21b.プリズム
1
2
22.反射鏡
20.PBS膜
21a.プリズム
a
d.全反射面
21d.プリズム
出射面
20.PBS膜
c.全反射面
21c.プリズム
b
1
2
21c.プリズム
20.PBS膜
c.全反射面
21d.プリズム
d.全反射面
出射面
c

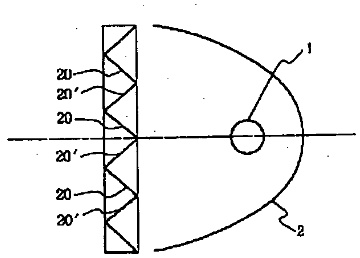
【図6】


21g.プリズム
20a.PBS膜
20b.PBS膜
1
2
21e.プリズム
21f.プリズム

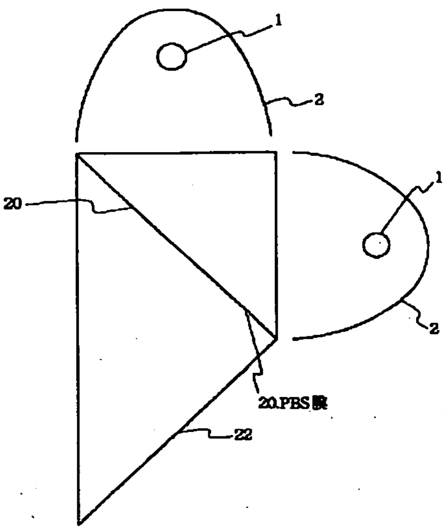
【図7】


22.反射面
θi
1
2
23
a
22
23
23
1
2
22
b

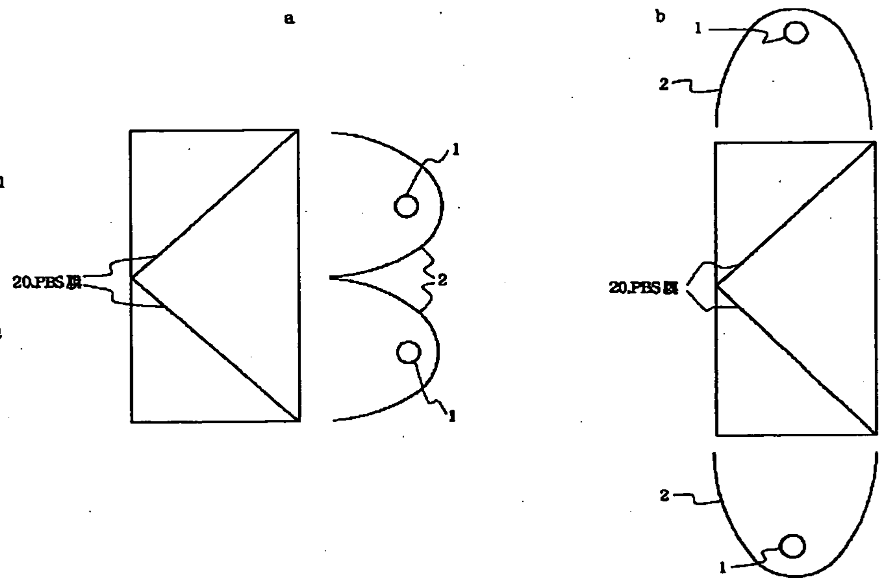
【図10】


20
20′
20
20′
20
20′
1
2

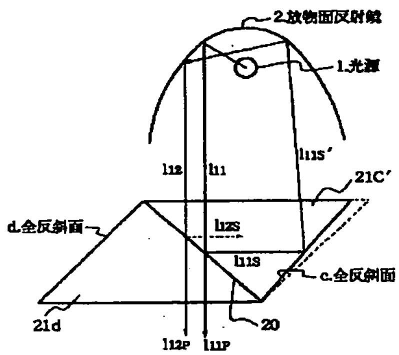
【図8】



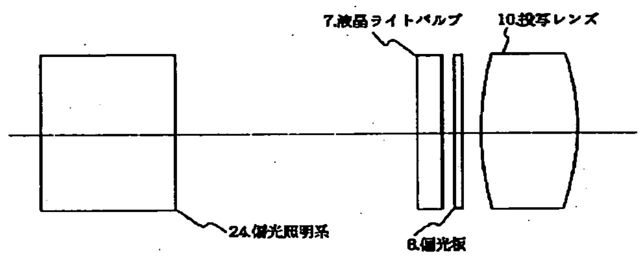
【図9】



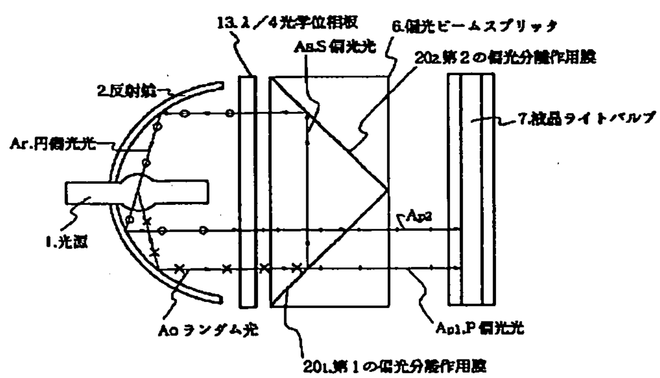
【図11】



【図12】



【図13】



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CLAIMS

[Claim(s)]
[Claim 1] The light source, the condensing means which consists of a reflecting mirror prepared in the tooth back of this light source, and a polarization separation means to divide the light from this condensing means into the 1st and 2nd polarization light from which the polarization direction differs mutually, The polarization lighting system characterized by modulating and carrying out outgoing radiation of the oscillating direction of said 1st polarization light by consisting only of a recursive means to return said 1st polarization light to said condensing means, and carrying out oblique incidence reflection of the 1st polarization light from said recursive means with the reflecting mirror of said condensing means.
[Claim 2] Said light source is a polarization lighting system according to claim 1 characterized by using the discharge tube mold light sources, such as a metal halide lamp and a xenon lamp.
[Claim 3] Said condensing means is a polarization lighting system according to claim 1 or 2 which is the body of revolution and column configuration **** which are constituted by the shape of a parabola, and is characterized by having arranged said light source near [parabolic / focus] this.
[Claim 4] Said condensing means is a polarization lighting system according to claim 1 or 2 characterized by having the body of revolution and column configuration **** which are constituted by elliptical, and having arranged said light source near the focus of this ellipse form.
[Claim 5] Said condensing means is a polarization lighting system according to claim 1, 2, 3, or 4 characterized by having a reflective means for returning the light which goes except said polarization separation means among the light emitted from said light source to said light source.
[Claim 6] The polarization lighting system according to claim 1, 2, 3, 4, or 5 characterized by being constituted so that said a part of first polarization light [at least] by which said recursive means is returned to said condensing means may not pass said light source.
[Claim 7] Said polarization separation means is a polarization lighting system according to claim 1, 2, 3, 4, 5, or 6 characterized by having the polarization segregation film which consists of dielectric multilayers.
[Claim 8] In the projection mold display which has a polarization lighting system, the image light means forming which forms image light by modulating the polarization light from this polarization lighting system, and a projection means to project the image light formed of this image light means forming A condensing means by which said polarization lighting system consists of a reflecting mirror prepared in the tooth back of the light source and this light source, A polarization separation means to divide the light from this condensing means into the 1st and 2nd polarization light from which the polarization direction differs mutually, The projection mold display characterized by modulating and carrying out outgoing radiation of the oscillating direction of said 1st polarization light by consisting only of a recursive means to return said 1st polarization light to said condensing means, and carrying out oblique incidence reflection of the 1st polarization light from said recursive means with the reflecting mirror of said condensing means.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the projection mold display which has a polarization lighting system and this polarization lighting system.

[0002]

[Description of the Prior Art] Drawing 13 is the important section block diagram showing one of the conventional examples of a projection display which used the polarization lighting system. For a reflecting mirror and 6, as for the polarization segregation film and 7, a polarization beam splitter and 20 are [1 / the light source and 2 / a liquid crystal light valve and 13] lambda / 4 optical phase plate. It sets to drawing 13 and they are two polarization segregation film 201. 202 The mutual edge has touched at the include angle of about 90 degrees. The random light Ao from the light source 1 which became abbreviation parallel light with the reflecting mirror 2 is the 1st polarization segregation film 201 of a polarization beam splitter 6. P polarization light Ap1 It is penetrated and S polarization light As is reflected. S polarization light As is the 2nd polarization segregation film 202 currently further installed in the optical path. It is reflected. After passing lambda / 4 optical phase plate 13 with which the optical axis is set up towards desired, Light Ap2 which contains P polarization light by becoming the circular polarization of light light Ar, and passing lambda / 4 optical phase plate 13 again through the light source 1 and a reflecting mirror 2 It becomes and is the polarization segregation film 201. It penetrates and incidence is carried out to the liquid crystal light valve 7.

[0003] This projection display is the polarization segregation film 201. Or 202 Both polarization light of P polarization light Ap and S polarization light As separated tends to be made into polarization light with the same polarization direction, it is not going to illuminate the liquid crystal light valve 7, and the rise of efficiency for light utilization can be aimed at compared with the projection display which does not use a polarization lighting system.

[0004]

[Problem(s) to be Solved by the Invention] However, in the conventional example, since the optical phase plate is used, in case light passes, the quantity of light will fall by absorption or reflection. Since the flux of light which carries out outgoing radiation once the optical phase plate made of a plastic currently generally used returns [which the permeability of light is about 90% and showed especially in the conventional example] to the light source 1 will pass an optical phase plate a total of 3 times, it will lose the quantity of light sharply.

[0005]

[Means for Solving the Problem] This invention is accomplished in order to solve the above-mentioned technical problem. This invention The light source, the condensing means which consists of a reflecting mirror prepared in the tooth back of this light source, and a polarization separation means to divide the light from this condensing means into the 1st and 2nd polarization light from which the polarization direction differs mutually, It consists only of a recursive means to return said 1st polarization light to said condensing means, and is characterized by modulating and carrying out outgoing radiation of the

oscillating direction of said 1st polarization light by carrying out oblique incidence reflection of the 1st polarization light from said recursive means with the reflecting mirror of said condensing means.
[0006]
[Example] The example of this invention is shown in drawing 1 .
[0007] As for the polarization segregation film (it is hereafter described as the PBS film), and 21a and 21b, the reflecting mirror with which 1 carried out the metal halide lamp as the light source, and 2 carried out the paraboloid-of-revolution configuration as a condensing means, and 20 are [a rectangular prism and 22] plane mirrors, and a polarization separation means consists of PBS film 20, rectangular prisms 21a and 21b, and a plane mirror 22. The light source 1 is formed in focal location 2c of a parabolic mirror 2, and can acquire the abbreviation parallel flux of light by this. The abbreviation parallel flux of light is divided into two linearly polarized light light by the polarization beam splitter, perpendicular reflection of one polarization light is carried out with the plane mirror 22 prepared in one outgoing radiation side of a polarization beam splitter, and it serves as the flux of light (it is hereafter described as recursive light) which returns to a parabolic mirror 2.
[0008] Next, a process until it obtains linearly polarized light light from the abbreviation parallel light which is indeterminate polarization light is explained concretely.
[0009] With a parabolic mirror 2, the beam of light l10 emitted from the core of the light source put on focal 2c of a parabolic mirror 2 becomes the parallel light l11, and carries out incidence to prism 21b. At this time, l11 is the natural light with the unfixed polarization direction. The beam of light l11 which reached the PBS film is linearly polarized light light l11P of the pair from which polarization segregation is received here and the polarization direction differs, and l11S. It dissociates. l11P have the polarization direction, i.e., the oscillating direction of polarization, in space, generally are called P polarization light, penetrate the PBS film 20, they progress, carry out outgoing radiation of the inside of 21a prism from the plane of incidence of a beam of light l11, and the outgoing radiation side in the opposite side, and become the polarization illumination light.
[0010] On the other hand, it is l11S. It is perpendicular to space, generally is called S polarization light, and is perpendicularly reflected by the PBS film 20, and the oscillating direction of polarization progresses the inside of 21b prism in the plane mirror 22 direction. A plane mirror 22 is S polarization light l11S. Since it is perpendicularly installed to the travelling direction, S polarization light changes a travelling direction 180 degrees, and progresses in the PBS film 20 direction again. l11S Since it is S polarization light, it is again reflected by the PBS film 20, and it becomes recursive light l11S ' to the return parabolic mirror 2 on the contrary about the same optical path as the time of having faced to the PBS film 20 (in order to make it intelligible by a diagram, the optical path before and behind reflection was shifted and shown). Since recursive light l11S ' is the parallel flux of light, it returns to the light source 1 which is reflected by point 2a on a parabolic mirror 2, and is in focal 2c.
[0011] Like the light emitted from the light source 1, again, toward a parabolic mirror 2, it is reflected with point 2b, and recursive light l11S ' becomes the parallel flux of light l12, and carries out re-incidence to prism 21b. The polarization condition is sharply disturbed by the situation mentioned later, and the parallel flux of light l21 is linearly polarized light light l12P of a pair with the PBS film 20. l12S It dissociates. l12P l11P Similarly, it is P polarization light, and the PBS film is penetrated, it progresses, outgoing radiation of the inside of prism 21a is carried out, and it becomes the polarization illumination light. On the other hand, it is l12S. l11S It acts as a recursive light which returns to the light source through a plane mirror 22 similarly. The above processes can be repeated and all the natural lights can be theoretically changed into polarization light.
[0012] It is separated by the polarization separation means and change of the polarization condition of the linearly polarized light light after being returned to the condensing means is explained using drawing 2 and drawing 3 .
[0013] In drawing 2 , the recursive light l21 is reflected with two-point 2a on a parabolic mirror 2, and 2b, it is set to l22 and l23, and outgoing radiation is carried out. In 2c, the focus of a parabolic mirror 2, and

~~Ga and Gb show Ha, and point 2a, the tangential plane of 2b, and Hb show the normal of point 2a and 2b.~~

[0014] the oscillating direction of the recursive light I21 — space — receiving — alphai only — it leans. alphai It is called an azimuth and the time of the oscillating direction turning clockwise to the propagation of light is made forward. Drawing 3 is this azimuth alphai. It explains, opening of the reflecting mirror 2 of drawing 1 is seen from the direction on which the PBS film is put, and it is the inside m1 of drawing 3 . It is in space in drawing 1 , and the field to include is m2. The field to include is perpendicular to space in drawing 1 . The drawing 3 Nakaya mark shows the oscillating direction of the recursive light I21. vibration to [this] alphai only — m3 which made it rotate The cut-off sectional view is drawing 2 .

[0015] the case where it reflects in the interface which whose recursive light I21 is linearly polarized light light as mentioned above, and has linearly polarized light light (for example, reflection by point 2a of drawing 2) — general — tanalphar =-tanalphai {cos (thetai-x)/cos (thetai+x)}
... one formula however — Sinx=sinthetai /n ... two formulas are materialized. alphai The azimuth at the time of the incidence of light I21 (as shown in drawing 3 , it will be called the oscillating direction and the angle which a flat surface m3 makes), and alphar Reflex time is the same and an azimuth and n are the refractive index of a parabolic mirror 2, and thetai. It is an incident angle over flat surfaces Ga and Gb ("the principle of optics, and the Tokai University publication meeting").

[0016] If a parabolic mirror 2 is a dielectric and refractive indexes n are the real number and a conductor, complex will be taken, and thereby, the method of change of the polarization condition after reflection is different.

[0017] The case where Dielectric n, i.e., a refractive index, is the real number first is described. n is the refractive index of the medium of the parabolic mirror 2 seen from the medium (drawing 2 air) of the space where light I21 is advancing, and is n> 1. For this reason, x is expressed with the real number from two formulas, and it is alphar from one formula. It becomes the real number. therefore, one formula — the oscillating direction — flat surface m3 from — it rotates in the direction keeping away ("principle of optics" P71). alphar at that time thetai One formula and two formulas show differing. Moreover, it is thetai so that drawing 2 may also show. Since all values are taken with 0<thetai <thetaimax (when point 2a of thetaimax is the edge of a parabolic mirror 2), the azimuth of light I22 also takes all values.

[0018] Moreover, an incident angle also in reflection with point 2b theta ib=pi / 2-thetaia ... Since all values are taken filling three formulas, as a result, all values may be taken, the oscillating direction of the outgoing radiation light containing the light I23 which advances the inside of the space of drawing 2 is scattering, and the azimuth of light I23 will also be in the condition of seeing in total and not polarizing. Naturally 2 is azimuth alphai of light I21 from it being a paraboloid-of-revolution mirror. Since all values are taken between -pi/2<alphai <pi/2, it turns out that polarization of the outgoing radiation light from a parabolic mirror 2 collapses in total also from this point.

[0019] Therefore, the light I23 through a parabolic mirror 2 is again divided into the linearly polarized light light in which a pair is different from each other with the PBS film 20 shown in drawing 1 .

[0020] On the other hand, when a parabolic mirror 2 is a conductor (i.e., when a refractive index n takes complex), situations differ. Since n is complex, x becomes complex from two formulas. Therefore, it is alphar from one formula. Since it becomes complex, generally the light I22 which the phase jump produced and reflected turns into elliptically-polarized-light light ("principle of optics" P911).

[0021] One of the requirements for becoming linearly polarized light light again, when elliptically-polarized-light light and the light I22 which became reflect in the following reflective spot 2b theta ia=theta ra=theta ib ... They are four formulas (thetara is the angle of reflection in point 2a). Because, linearly polarized light light is incident angle thetai. When it is reflected by angle-of-reflection thetar (=thetai), phase contrast delta arises and it becomes elliptically-polarized-light light by the interface which carried out incidence, if the elliptically-polarized-light light of phase contrast-delta carries out incidence to the same interface and is reflected by incident angle thetar (=thetai) from the reverse nature of light, it will become linearly polarized light light. That is, it is necessary for linearly polarized

light light and the elliptically-polarized-light light whose phase contrast is delta to fill at least 4 formulas, in order to become reversible by reflection.

[0022] Now, since it is theta ia+theta ib=pi / 2, generally four formulas are not filled. It compares, and even if it fills, unless phase contrast arises only pi/2, respectively in reflective spot 2a of a parabolic mirror 2 like drawing 2 , and 2b, I23 cannot become linearly polarized light light with the same oscillating direction as I21. Therefore, since you may think that I23 does not become linearly polarized light light, it is the PBS film 20 shown by drawing 1 , and it is clear to separate into the linearly polarized light light of a pair.

[0023] By the way, the situation where the oscillating direction does not rotate through a parabolic mirror 2 by being in agreement that is, but always act as an S polarization light to the PBS film, come and go a plane mirror 22 and a parabolic mirror 2 through the PBS film 20, and it does not act as illumination light produces the oscillating direction of light I21 and light I23 at the time of azimuth alphai =0 or pi/2.

[0024] Moreover, it says [that rotation (change of alpha) of the oscillating direction is small, and there are few components of P polarization light to the PBS film 20 of light I23 than the component of S polarization light at the time of reflection in the reflector of a dielectric], At the time of reflection in the reflector of a conductor, conditions, like the phase contrast to produce is small arise, it may become the elliptically-polarized-light light near linearly polarized light light, and that there are similarly few components of P polarization light to the PBS film 20 may arise. When such, in order to disturb the oscillating direction of the recursive light I21 positively, it is good to make the front face of a light source lamp into the diffusing surface.

[0025] The capacity of the diffusing surface for the diffusing surface to be considered to be the condition that many minute prism usually covered the front face, and for the capacity to change the oscillating direction of polarization light to prism to change the oscillating direction of polarization light since it is general very small is very small. The polarization light I22 which the travelling direction of light could be changed, for example, had a certain oscillating direction like drawing 4 diffuses the diffusing surface on the front face of the light source 1. However, the polarization light I221, By branching like I222, I223, and I224 and reflecting by various incident angles and the azimuth in respect of [various] a parabolic mirror 2 Polarization light I231 which is different, respectively in addition to polarization light I23, I232, and I233 It can obtain and the oscillating direction of polarization light can be disturbed further.

[0026] The reason for establishing the diffusing surface in a lamp front face or near is for making it act like the light which emitted the light diffused in the diffusing surface from the light source 1. If the diffusing surface is located in the other location, abbreviation parallel light is no longer obtained by the condensing means.

[0027] Generally the PBS film of this example was formed of dielectric multilayers, was inserted between two rectangular prisms 21a and 21b, and is pasted up, and it is the polarization beam splitter generally said. It is designed so that it may separate into P polarization light and S polarization light to the light whose incident angle is 45 degrees. Unless an angle of incidence shifts from 45 degrees sharply, the polarization beam splitter corresponding to the light of other angles of incidence can also be manufactured.

[0028] although that the plane mirror 22 generally carried out [that] aluminum vacuum evaporationo on the glass flat surface is used — the increase for the improvement in a reflection factor — reflection — a coat — you may cope with preparing etc. Moreover, it must be installed so that a reflector may become perpendicular to the travelling direction of S polarization light separated by the polarization beam splitter.

[0029] Since the light source 1 is emitting a lot of infrared light, a parabolic mirror 2 is good to form by the cold mirror, in order to prevent the temperature up of the illuminated body. Generally at this example, the configuration of the cross section is y=ax2. Although the reflecting mirror of the paraboloid-of-revolution configuration which can be expressed was used, in order to raise condensing

nature more according to the luminescence property of the light source, the thing with the cross-section which can be expressed with y=ax2+bx4+cx6 (a>>b, c) of an abbreviation parabola may be used. Moreover, the condensing means which combined an elliptical reflecting mirror and an elliptical refraction component may be used. In addition, the cross-section configuration of the flux of light by which outgoing radiation is carried out from a condensing means, using an auxiliary mirror in constituting from two or more mirror planes **** can be adjusted, and if the condensing means which introduced other aspheric surfaces is the configuration that abbreviation parallel light is obtained in order to raise the rate of condensing, almost all the condensing means is applicable. However, since the way with many counts of reflection in the reflecting mirror of light returned to the condensing means can disturb the oscillating direction of polarization light more more preferably if there is little loss in reflection, it is desirable.

[0030] The polarization lighting system of this invention is revolution of the oscillating direction of the linearly polarized light light in 1. reflex time since it is still linearly polarized light light in order that the recursive light which faces to the reflecting mirror of a condensing means may not pass lambda / 4 optical phase plate like the conventional example.

2. Modulation from linearly polarized light light furthermore according to phase jump of reflex time case of reflecting mirror of conductor to elliptically-polarized-light light.

Recursive light can be made into the light which can be again divided into P polarization light and S polarization light by the PBS film 20 according to an operation of two **.

[0031] Other examples of the polarization lighting system of this invention are shown below.

[0032] Drawing 5 (a) has Prism 21a and 21b and the composition that P polarization light separated by the polarization beam splitter formed by the PBS film 20 is returned to the condensing means 2, i.e., a parabolic mirror, with a parabolic mirror 22, and serves as a difference over the point of returning S polarization light in the 1st example to a condensing means.

[0033] Drawing 5 (b) reaches and pastes up the example of drawing 5 (c) by ************ by the triangle pole prism 21c and 21d by which the cross section carried out the configuration of a right triangle for the PBS film 20. The light which carried out incidence to prism 21c through the condensing means (parabolic mirror 2) in drawing 5 (b) reaches the PBS film 20 or the total reflection side c. The light which reached the PBS film 20 is separated into S polarization light and P polarization light by the PBS film 20, outgoing radiation of the P polarization light is carried out from a prism 21d outgoing radiation side, and S polarization light turns into recursive light which is reflected by the PBS film, reaches the total reflection side c, is reflected further here, and returns to a condensing means.

[0034] It is reflected here and the light which, on the other hand, reached the total reflection side c among the light which carried out incidence to prism 21c faces to the PBS film 20. And it is separated into S polarization light and P polarization light by the PBS film 20, and S polarization light turns into recursive light which is reflected and tends toward a condensing means. It is reflected by the total reflection side d and outgoing radiation of the P polarization light is carried out from an outgoing radiation side.

[0035] The light which carried out incidence to prism 21c through the condensing means (parabolic mirror 2) in drawing 5 (c) also reaches the PBS film 20 or the total reflection side c. The light which reached the PBS film 20 is separated into S polarization light and P polarization light by the PBS film 20, outgoing radiation of the P polarization light is carried out from the back outgoing radiation side reflected by the total reflection side d, and S polarization light turns into recursive light which is reflected by the PBS film, reaches the total reflection side c, is reflected further here, and returns to a condensing means.

[0036] It is reflected here and the light which, on the other hand, reached the total reflection side c among the light which carried out incidence to prism 21c faces to the PBS film 20. And it is separated into S polarization light and P polarization light by the PBS film 20, and S polarization light turns into recursive light which is reflected and tends toward a condensing means. Outgoing radiation of the P

polarization light is carried out from a prism 21d outgoing radiation side.
[0037] In the example of drawing 6 , three triangle pole prism 21e, 21f, and 21g with which the cross section carried out the configuration of a right triangle is together put, as shown in drawing, and the PBS film 20a and 20b is formed in the interface of each prism.
[0038] The light which has carried out incidence through a parabolic mirror 2 penetrates prism 21e, and is separated into P polarization light and S polarization light by the PBS film 20a or 20b, outgoing radiation of the P polarization light is carried out from an outgoing radiation side as it is, and S polarization light turns into recursive light which is reflected by the PBS film of another side and returns to a parabolic mirror 2.
[0039] Since the part formed by prism compared with the example in drawing 1 or drawing 5 (a) becomes the volume of abbreviation one half, the example shown by drawing 5 (b), drawing 5 (c), and drawing 6 also has the effectiveness that a compact and a cheap polarization lighting system are realizable.
[0040] The example of drawing 7 uses the glass monotonous layer 23 instead of PURISUMU and the PBS film which were used in said each example. Generally it is brewster's-angle thetai. Even if it will not form the PBS film if two or more glass plates are piled up since it has a polarization separation property also with a glass plate if it is maintaining, it can consider as a polarization separation means. Although it becomes good, since permeability may become low, polarization separability ability may prepare the PBS film by dielectric multilayers between glass plates if needed, so that there is much number of sheets to pile up. The plane mirror 22 is perpendicularly arranged to said light reflected so that the light reflected in the glass monotonous layer 23 may be returned by the same optical path.
[0041] Drawing 7 (b) is the application of drawing 7 (a), as one unit, sets a symmetry axis as the optical axis of a condensing means, and forms the glass monotonous layer 23 and 2 sets of plane mirrors 22.
[0042] The example of drawing 7 (a) and (b) becomes lightweight and cheap compared with the example which used prism. Moreover, although components mark of the example of drawing 7 (b) increase to the example of drawing 7 (a), there is a merit that it can miniaturize.
[0043] In addition, like the example shown by drawing 1 , by reflection with the parabolic mirror 2 which is a condensing means, the recursive light returned to a condensing means in the example of drawing 7 from drawing 5 has a polarization condition disturbed, and carries out outgoing radiation from a condensing means again.
[0044] Drawing 8 is other examples and has 2 sets of light sources, and a condensing means. S polarization light reflected by the PBS film 20 among the light from one condensing means is constituted so that it may tend toward the condensing means of another side, and it is equipped with prism 21h which has the reflector 22 for turning P polarization light which penetrate the PBS film 20 among the light from both condensing means in the same direction.
[0045] Drawing 9 is other examples and has 2 sets of light sources, a condensing means, and the PBS film. S polarization light reflected by one PBS film among the light from one condensing means consists of drawing 9 (a) so that it may tend toward the condensing means of another side through the PBS film of another side, and outgoing radiation of the P polarization light which penetrate the PBS film among the light from both condensing means is carried out in the same direction.
[0046] P polarization light which penetrated one PBS film among the light from one condensing means consists of drawing 9 (b) so that it may tend toward the condensing means of another side through the PBS film of another side, and outgoing radiation of the S polarization light reflected by the PBS film among the light from both condensing means is carried out in the same direction.
[0047] Since the two light sources are used for the example of drawing 8 and drawing 9 , it can measure a steep quantity of light rise. Usually, although it is possible to raise the output of the light source simply for raising the quantity of light, if the output of the light source is raised, the light-emitting part of the light source will become large inevitably, and the parallelism of the light through a condensing means will worsen. Since it becomes a requirement that the illumination light is close to parallel light when

illuminating the illuminated body with angular dependence like a liquid crystal light valve, it is very desirable that a quantity of light rise can be aimed at without enlarging a light-emitting part like this example.

[0048] Other examples are shown in drawing 10 . This example makes small drawing 5 (b) or the component by the prism of the example of drawing 6 , and arranges them in on the same flat surface. [two or more] In this Fig., 20 is the PBS film and 20' is the PBS film or the reflective film.

[0049] Next, the example for making the fall of the parallelism of recursive light into the minimum is shown below. If constituted from a bulb section front face of a lamp for the business on which recursive light is scattered, since said recursive light will act by making a lamp bulb section front face into the secondary light source, it means that the path of a lamp had become large substantially, and parallelism will fall. Therefore, what is necessary is just to use the light source in which dispersion does not occur on the bulb section front face of a lamp, in order to make the fall of parallelism into the minimum. Approaches, such as specifically smoothing the bulb section of a lamp, can be considered. Moreover, since the xenon lamp can generally form the bulb section smoothly from a metal halide lamp, it becomes easy to form the lamp which cannot be easily scattered about even if light is equivalent to the bulb section of a lamp.

[0050] Furthermore, the example for preventing being absorbed in case recursive light passes the lamp bulb section and a light-emitting part, as a result becoming loss light is shown in drawing 11 .

[0051] The place where this example differs from the example of drawing 5 (b) is only the point which transposed prism 21c to prism 21c'.

[0052] This example makes acute-angle prism 21c' (the cross section containing a drawing destructive line is a right triangle) equipped with 21d of rectangular prisms which carried out the configuration of the triangle pole which makes a right triangle a cross section, the field whose right angle of 21d of these rectangular prisms is pinched, and the same form and a field with the same area near a right angle rival, as shown in drawing, and forms the PBS film 20 in a lamination side. In addition, the PBS film 20 which is multilayers may be formed only in one of the fields of 21d of rectangular prisms, and acute-angle prism 21c, may be made to rival, and it may prepare in a mutual field and it may be made to rival. Moreover, aluminum vacuum evaporationo etc. may be given to the total reflection sides c and d if needed.

[0053] The parallel light l11 made parallel through the parabolic mirror 2 in drawing 11 is P polarization light l11P among the parallel light l11 by the PBS film 20. It penetrates as it is and outgoing radiation is carried out from 21d of rectangular prisms. S polarization light l11S reflected by the PBS film 20 on the other hand It is reflected in respect of [c] total reflection, and becomes recursive light l11S '. Since the PBS film 20 and the total reflection side c are not making the right angle, recursive light l11S ' faces to a parabolic mirror 2, without becoming parallel [said parallel light l11]. Recursive light l11S ' tends toward the light source 1 put on the focal location of this parabolic mirror 2 through the parabolic mirror 2. Here, since it is the same as that of the 1st example, the principle in which the oscillating direction of polarization light is in disorder by reflecting with a parabolic mirror 2 is omitted. Moreover, as mentioned above, recursive light l11S ' does not tend toward the light source 1 correctly, even if it is reflected with a parabolic mirror 2, since it is not parallel to the parallel light l11, but will avoid a light-emitting part and will pass. Recursive light l11S which avoid a light-emitting part, and are not passed that is, absorbed by the light-emitting part It becomes light l12 through a parabolic mirror 2 again, and is optical l12P with reentry putting and the PBS film 20 to prism 21c'. Optical l12S It dissociates again. Since the place referred to as that the optical axis of the flux of light which returns to a parabolic mirror 2 and the light source 1 through the PBS film 20 in this example does not pass the light-emitting part of the light source is essence, you may set up so that the total reflection side c may make the parallel light l11 and 45 degrees and the PBS film 20 may make angles other than the parallel light l11 and 45 degrees. Moreover, the optical path of recursive light can be prevented from passing a light-emitting part by giving curvature to both the PBS film 20, and total reflection both [one side or] c. What should be minded at this time is that the incident angle to the PBS film 20 of the light l12 which was no longer

parallel light does not exceed sharply the permission include angle of the PBS film 20 with angular dependence.
[0054] Although this example can be considered to be the application of drawing 5 (b), the same effectiveness as this example can be given by changing the plane mirror for returning light in the direction of the light source also in other examples, and the inclination of a total reflection side, or giving curvature.
[0055] The example of the projection mold display of this invention is shown in drawing 12 . The polarization lighting system 24 uses either of the examples which were mentioned above.
[0056] The polarization light from the polarization lighting system 24 serves as the flux of light which contained image information by passing the liquid crystal light valve 7, only image light is penetrated with a polarizing plate 8, and this image light is projected on a non-illustrated screen through the projection lens 10.
[0057] Color-separation optical system may be established between the polarization lighting system 24 and the liquid crystal light valve 7, the color composition optical system 5 may be established between the liquid crystal light valve 7 and the projection lens 10, and a liquid crystal light valve may be prepared for every optical path of each color. Moreover, a part or all of color-separation optical system may be established between the condensing means of a polarization lighting system, and a polarization separation means. In this case, although two or more polarization separation means are needed, since there is generally a wavelength dependency in the PBS film, if it carries out easy [of the PBS film suitable for each colored light] after separating the color, a good design will be attained [rather than] about an effectiveness rise and good color reproduction nature.
[0058] Moreover, it may project with two or more projection lenses, without using color composition optical system, two or more image light may be compounded on a screen, two or more polarization lighting systems may be prepared, without using color-separation optical system, and the liquid crystal light valve corresponding to them may be illuminated.
[0059] In the example of drawing 12 , if the polarizing plate as an analyzer is prepared in front of the liquid crystal light valve 7, the polarization ratio of the polarization light which carries out incidence to the liquid crystal light valve 7 can be raised further.
[0060] In addition, this invention is the range which is not limited to the above example and does not deviate from the main point of invention, and it cannot be overemphasized that various configurations are possible.
[0061]
[Effect of the Invention] A condensing means by which this invention consists of a reflecting mirror prepared in the tooth back of the light source and this light source as explained above, A polarization separation means to divide the light from this condensing means into the 1st and 2nd polarization light from which the polarization direction differs mutually, It consists only of a recursive means to return said 1st polarization light to said condensing means, and since outgoing radiation of the oscillating direction of said 1st polarization light is modulated and carried out by carrying out oblique incidence reflection of the 1st polarization light from said recursive means with the reflecting mirror of said condensing means, few polarization lighting systems of loss of light are realizable. Moreover, since lambda / 4 optical phase plate generally has a wavelength dependency, it is effective that the oscillating direction of polarization light can be modulated without using lambda / 4 optical phase plate also for the purpose of preventing an irregular color.

[Translation done.]

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The operation explanatory view of the example of the polarization lighting system of this invention
[Drawing 2] The principle explanatory view of an operation of the polarization lighting system of this invention
[Drawing 3] The principle explanatory view of an operation of the polarization lighting system of this invention
[Drawing 4] Other examples of the polarization lighting system of this invention
[Drawing 5] Other examples of the polarization lighting system of this invention
[Drawing 6] Other examples of the polarization lighting system of this invention
[Drawing 7] Other examples of the polarization lighting system of this invention
[Drawing 8] Other examples of the polarization lighting system of this invention
[Drawing 9] Other examples of the polarization lighting system of this invention
[Drawing 10] Other examples of the polarization lighting system of this invention
[Drawing 11] Other examples of the polarization lighting system of this invention
[Drawing 12] The example of the projection mold display of this invention
[Drawing 13] The outline block diagram of the conventional projection mold display
[Description of Notations]
1 Light Source
2 Reflecting Mirror
7 Liquid Crystal Light Valve
6 Polarization Beam Splitter
8 Polarizing Plate
10 Projection Lens
13 Lambda / 4 Optical Phase Plate
20 Polarization Segregation Film (PBS Film)
21 Prism
22 Plane Mirror
24 Polarization Lighting System

[Translation done.]